IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	YAMADA ET AL.	Group Art Unit: 2879
Serial No.	09/656,482	Examiner: K. Berck
Filed:	September 7, 2000	
For:	SEALING STRUCTURE FOR ELECTROLUMINESCENCE DISPLAY DEVICE	

DECLARATION UNDER 37 CFR 1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

We, Tsutomu Yamada of Motosu-gun, Gifu, Japan and Naoaki Komiya of Ogaki-shi, Gifu, Japan, declare that:

1. We are the named inventors of the above-captioned U.S. patent application.

2. We are informed that Ebisawa et al. (U.S. Patent No. 6,284,342) has a filing date of June 11, 1999 and was cited in an office action in the above-captioned U.S. application.

3. We are also informed that Ebisawa et al. has been used to reject claims 15, 16, 18-21, 24, and 37.

4. We conceived of the invention disclosed and claimed in the above-captioned U.S. application prior to June 11, 1999. We conceived of the invention in Japan, which is a WTO country.

5. The invention claimed in claims 15, 16, 18-21, 24, and 37 was described in our Japanese patent application No. Hei 10-277997, which was filed in Japan on September 30, 1998.

6. We are submitting with this Declaration a verified English translation of Japanese patent application No. Hei 10-277997. The entire document is relevant.

7. Because the application was drafted and filed in the Japanese patent office, the invention was reduced to practice by the filing date of the Japanese patent application No. Hei 10-277997 with the Japanese patent office.

8. Because Japanese patent application No. Hei 10-277997 was drafted and filed with the Japanese patent office on September 30, 1998, the invention that is claimed in claims 15, 16, 18-21, 24, and 37 was conceived and reduced to practice by September 30, 1998.

The undersigned declare that all statements made herein of their own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.

Date: October 20, 2003

Tsutomu Yamada

Tsutomu Yamada

Date: October 12, 2003

Naoaki Komiya

Naoaki Komiya

DECLARATION FOR TRANSLATION

I, Jun Ishida, a Patent Attorney, of 1-34-12, Kichijoji-Honcho, Musashino-shi, Tokyo, Japan, do solemnly and sincerely declare that I well understand the Japanese and English languages and that the attached English version is a full, true and faithful translation made by me

this 12th day of September 2003

of the Japanese Patent Application of

No. Hei 10-277997

entitled "Organic Electroluminescence Display Device".

In testimony thereof, I herein set my name and seal

this 12th day of September 2003

Jun Ishida
Patent Attorney

[Document] APPLICATION FOR PATENT

[Identification No. of Document] KHB0980043

[Filing Date] September 30, 1998

[Addressee] Esq. Commissioner of the Patent Office

[IPC] H05B 33/26

[Title of the Invention] Organic Electroluminescence Display Device

[Number of Claims] 4

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[Number] 1

[Name of Item] Drawings
[Number] 1

[Name of Item] Abstract
[Number] 1

[General Power of Attorney No.] 9702954

[Necessity of Proof] Yes

Japanese Patent Application No. Hei 10-277997

[Name of the Document] Specification

[Title of the Invention] Organic Electroluminescence Display Device

[Claims]

[Claim 1] An organic electroluminescence display device comprising a pair of substrates having a first electrode, an emissive layer composed of an organic material, and a second electrode disposed between said substrates, wherein

a spacer is provided between said first electrode and either one of said substrates, said spacer comprising a desiccant.

[Claim 2] An organic electroluminescence display device comprising a pair of substrates having a first electrode, an emissive layer composed of an organic material, and a second electrode disposed between said substrates, wherein

said pair of substrates are adhered to one another at their surrounding portions by a sealing agent having a desiccant mixed therein.

[Claim 3] An organic electroluminescence display device comprising a pair of substrates having a first electrode, an emissive layer composed of an organic material, and a second electrode disposed between said substrates, wherein

a concave groove is formed in at least one of said pair of substrates at a surrounding portion thereof, and a desiccant is filled in said groove.

[Claim 4] An organic electroluminescence display device as defined in any one of Claims 1 to 3, wherein

one of said pair of substrates is provided with a thin film transistor including a source and a drain, and an organic electroluminescence element composed by laminating in order over said thin film transistor an anode connected to said source or drain, an emissive layer, and a cathode, said organic electroluminescence element being driven by said thin film transistor; and

the other one of said pair of substrates includes a color component.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a display device formed by disposing, on a substrate, an electroluminescence (hereinafter referred to as "EL") element and a thin film transistor (hereinafter referred to as "TFT").

[0002]

[Background Art]

In recent years, display devices using organic EL elements are regarded as devices that may replace both CRTs and LCDs.

[0003]

Fig. 4 is a partial cross-sectional view of a conventional color display device including an organic EL element and TFT.

[0004]

As shown in the Figure, a gate electrode 3, a gate insulation film 4, an active layer 5 composed of polysilicon and including a source region 6 and a drain region 7, and an interlayer insulation film 8 are formed on an insulator substrate 2 made of a material such as glass or synthetic resin. Over the interlayer insulation film 8, a fluorescent conversion layer 9 composed of an organic material is formed in a region corresponding to an anode 12 later disposed for each display pixel 1. The fluorescent conversion layer 9 serves to convert a colored light, which may be blue, irradiated from an emissive layer 14 into another color. Subsequently, a drain electrode 10 connected to the drain region 7 is formed, and a planarizing insulation film 11 is formed over the entire surface. The anode 12 of an organic EL element is then formed using ITO (indium tin oxide). The anode 12 is connected to the source region 6 via a contact hole created in the planarizing insulation film 11. In this manner, a TFT which serves as a switching element for an organic EL element is completed.

[0005]

An organic EL element is next formed over the TFT described above.

[0006]

An organic EL element is formed by laminating, in order, the anode 12 connected to the source region 6 and composed of a transparent conductive material such as ITO, a second hole-transport layer 16 made of MTDATA (4,4'-bis(3-methylphenylphenylamino)biphenyl), a first hole-transport layer 15 composed of TPD (4,4',4"-tris(3-methylphenylphenylamino)triphenylanine), an emissive layer 14, an electron transport layer 13 formed of $Bebq_2$, and a cathode 17 made of magnesium-indium alloy (MgIn). As such, each of the layers 13, 14, 15, and 16 are composed of organic compounds, and the organic EL element is configured with those layers in addition to the anode 12 and the cathode 17.

[0007]

In the above-described organic EL element, holes injected from the anode 12 and electrons injected from the cathode 17 recombine within the emissive layer 14. As a result, organic molecules constituting the emissive layer 14 are excited, generating excitons. Through the process in which these excitons undergo radiation until deactivation, light is emitted from the emissive layer 14. This light radiates outward through the transparent anode 12 via the transparent insulator substrate 2 (in the direction indicated by arrows in the drawing), resulting in light emission.

[0008]

The surface of the organic EL element formed by laminating layers as described above is covered with a cap 18 composed of a metal such as aluminum. The cap 18 is adhered to a surrounding portion of the insulator substrate 1 using a seal 19 comprising a sealing agent such as epoxy. Barium oxide (BaO) is disposed on the inside of the cap 18. The space 21 between the cap 18 and the cathode 17 is filled with a gas such as nitrogen gas (N_2).

[0009]

In this manner, a conventional organic EL display device is completed.

[0010]

[Problems to be Solved by the Invention]

According to the above-described conventional display device structure, the direction of light emission from the organic EL element is towards the insulator substrate 2 provided with the TFT. The emitted light is therefore blocked by the TFT, resulting in limited aperture ratio of the display pixel 1.

[0011]

Further, according to the conventional structure, the size of the TFT must be reduced as much as possible to minimize blocking of the emitted light. Because of this restriction, TFT size and TFT performance also become limited.

[0012]

In light of the above existing disadvantages, the present invention was created to provide an organic EL display device in which the aperture ratio of each display pixel is enhanced, the size and driving capability of the TFT for driving an EL element can be more freely selected, and the manufacturing process is simplified by disposing a color component on a separate substrate arranged opposing the substrate having the TFT formed thereon.

[0013]

[Means for Solving the Problem]

An organic electroluminescence display device according to the present invention comprises a pair of substrates having a first electrode, an emissive layer composed of an organic material, and a second electrode disposed between the substrates. A spacer is provided between the first electrode and either one of the substrates, and the spacer comprises a desiccant.

[0014]

According to another aspect, the present invention is an organic electroluminescence display device comprising a pair of substrates having a first electrode, an emissive layer composed of an organic material, and a second electrode disposed between the substrates, wherein the pair of substrates are adhered to one another at their surrounding portions by a sealing agent having a desiccant mixed therein.

[0015]

According to a further aspect, the present invention is an organic electroluminescence display device comprising a pair of substrates having a first electrode, an emissive layer composed of an organic material, and a second electrode disposed between the substrates, wherein a concave groove is formed in at least one of the pair of substrates at a surrounding portion thereof, and a desiccant is filled in the groove.

[0016]

According to a still further aspect, the present invention is an organic electroluminescence display device as described above, wherein one of the pair of substrates is provided with a thin film transistor including a source and a drain, and an organic electroluminescence element composed by laminating in order over the thin film transistor a cathode connected to the source or drain, an emissive layer, and an anode. The organic electroluminescence element is driven by the thin film transistor. The other one of the pair of substrates includes a color component.

[0017]

[Embodiments of the Invention]

<First Embodiment>

An organic EL display device according to the present invention is next described.

[0018]

Fig. 1 shows a cross-sectional view of a first embodiment of an organic EL display device which includes color filters 23 as the color component and comprises a first substrate 2 and a second substrate.

[0019]

Each display pixel 1 is formed by laminating a TFT and an organic EL element on an insulator substrate 2. The insulator substrate 2 may be a substrate made of an insulating material such as glass or synthetic resin, or may be formed by depositing an insulating thin film such as SiN film or SiO_2 film on the surface of a conductive substrate or semiconductor substrate. Display pixels 1 are arranged in a matrix to form a color display panel. The insulator substrate 2 may be transparent or opaque.

The TFT is, as shown in Fig. 1, a bottom-gate type TFT having a gate electrode 3 disposed under a gate insulation film 4. Because the structure of the TFT is identical to a conventional structure using polysilicon as the active layer, no further explanation of the TFT will be given.

[0020]

A source region 9 of the TFT is connected to an anode 12 of an organic EL element.

[0021]

The anode 12 is formed by providing molybdenum (Mo) 12', which is an opaque conductive material, on the surface of a planarizing insulator film 11 and through a contact hole created in the planarizing insulator film 11, and further depositing ITO on top. Mo

and ITO may be formed in identical shapes. Mo is provided so as to reflect and efficiently radiate light generated in an emissive layer. The opaque conductive material is not limited to Mo, and may alternatively be a metal such as aluminum (Al) or silver (Ag). ITO is provided on top because of its high work function, so as to efficiently perform light emission from Mo and the emissive element layer.

[0022]

The organic EL element is formed by laminating, in order, a cathode 17 composed of a transparent conductive material such as ITO; a second hole-transport layer 16 made of MTDATA (4,4'-bis(3-methylphenylphenylamino)biphenyl); a first hole-transport layer 15 composed of TPD (4,4',4"-tris(3-methylphenylphenylamino)triphenylanine); an emissive layer 14; an electron transport layer 13 formed of $Bebq_2$; a buffer layer BL composed of a material having high work function, such as an alkali metal which may include lithium and sodium, an alkaline earth metal which may include potassium, calcium, and magnesium, or a fluorine compound of these metals; and the anode 12 connected to the source region 9.

[0023]

Light emitted from the organic EL element is radiated outward through the transparent cathode 17 (in the page upward direction indicated by the arrows in the drawing). In other words, light emission is performed toward the side of an insulator substrate 22, the side on which TFTs are not provided. It is to be noted that the cathode 17 is a common electrode formed on the entire surface, as shown in Fig. 1.

[0024]

Next described are the color filters 23 formed on the insulator substrate 22 as the color component.

[0025]

The color filters 23 are provided as the color component in the display panel of the above-described organic EL display device.

[0026]

As shown in Fig. 1, on the side facing the cathode 17, color filters 23 including red (R), green (G), and blue (B) filters are formed on the transparent insulator substrate 22 made of a material such as a transparent film or glass substrate.

[0027]

The color filters 23 are positioned on the transparent insulator substrate 22 on the side facing the cathode 17 of the organic EL element. The transparent insulator substrate 22 and the insulator substrate 2 are adhered and fixed onto one another at their surrounding portions using a sealing agent 19 having adhesive function. It is to be noted that the color filters 23 for the respective colors are provided in each display pixel 1 comprising an organic EL element and TFT. Black matrix (BM) 24 for shielding light may be disposed between discrete color filters.

[0028]

Light emitted from the emissive layer of the organic EL element is radiated in the direction indicated by the arrows through the color filters 23 to generate the respective colors.

[0029]

The emissive material used in the emissive layer of the organic EL element is next described.

[0030]

An emissive material used in the emissive layer 14 of the organic EL element is selected in accordance with the type of color component provided over the organic EL element. More specifically, when color filters of R, G, and B are used as in the present embodiment, white light is employed as the light emitted from the organic EL element.

[0031]

To achieve emission of white light, a material for the emissive layer 14 may comprise, for example, ZnBTZ complex, or a laminated structure composed of TPD (aromatic diamine), p-EtTAZ (1,2,4-triazol derivative), and Alq ("Alq" referred to herein denotes Alq partially doped with Neal red which is a red light emitting pigment).

[0032]

The sealing agent for adhering the transparent insulator substrate 22 to the insulator substrate 2 is next explained.

[0033]

The sealing agent 19 for adhering the two substrates 2, 22 is composed of an epoxy resin having a desiccant such as calcium oxide, phosphorus pentaoxide, calcium chloride, or silica gel mixed therein. By mixing a desiccant in the sealing agent, moisture inside the space defined by the two substrates 2,22 and the sealing agent 19 can be absorbed by the desiccant. As a result, display deterioration due to harmful effects by the moisture on each layer composed of organic materials can be prevented.

[0034]

As such, in an organic EL display device according to the present invention, light can be radiated towards the side of the transparent insulator substrate 22 provided with the color filters 23 without being blocked by the TFTs. The display device can therefore be designed with the maximum aperture ratio for each display pixel 1. In addition, increased freedom is available in selecting the size and driving capability of the TFTs.

[0035]

Furthermore, as the aperture ratio of the display pixels can be enhanced, it is no longer necessary to increase current density to obtain a bright indication. Accordingly, the life of the organic EL element can be extended.

[0036]

Moreover, in the present embodiment, only one type of white light emitting material is required as the emissive material for the emissive layer of the organic EL element. The color filters of the three colors R, G, and B are arranged on the transparent substrate 22, and the color filter side of the transparent substrate 22 is adhered to the cathode side of the organic EL element. This manufacturing process is much simpler than the conventional manufacturing process in which three types of organic EL materials are arranged in the organic EL element layer for generating the respective primary colors.

[0037]

Further, as the generated light is emitted as the colors of the display pixels via the color filters disposed on the cathode side in the present embodiment, color emitting areas are larger compared to a conventional device in which light is emitted from the TFT substrate side. Accordingly, color indication having increased brightness and vividness can be obtained.

<Second Embodiment>

Fig. 2 shows a cross-sectional view of a display device in which a fluorescent conversion layer is employed as the color component.

[0038]

As can be seen in Fig. 2, the present embodiment differs from the first embodiment in that the fluorescent conversion layer 9 is formed on the transparent insulator substrate 22 in place of the color filters 23. Further differing from the first embodiment, the organic EL layer 14 comprises, for example, a blue light emitting material, and spacers 25 composed of a desiccant are disposed between the fluorescent conversion layer 9 and the cathode 17.

[0039]

A fluorescent conversion layer 9 is formed in a position corresponding to the anode 12 by depositing an organic material using an evaporation method on the transparent insulator substrate 22 which may be a glass substrate. Subsequently, the transparent insulator substrate 22 having the fluorescent conversion layer 9 formed thereon and the insulator substrate 2 are adhered to one another by the adhesive sealing agent 19 such that the fluorescent conversion layer 9 faces the anode 17.

[0040]

Spacers 25 are arranged between the fluorescent conversion layer 9 and the cathode 17 so as to absorb moisture within the region defined by the insulator substrate 2, transparent insulator substrate 22, and the fluorescent conversion layer 9. This arrangement of the spacers 25 can simultaneously serve to retain space between the fluorescent conversion layer 9 and the cathode 17.

[0041]

The spacers 25 may be composed of a desiccant such as calcium oxide, phosphorus pentaoxide, calcium chloride, and silica gel. The diameter of the spacers 25 is of a size

sufficient for retaining the space, and may be, for example, approximately between several μm and several hundred μm.

[0042]

The fluorescent conversion layer 9 will next be described for an example case in which a blue emissive material is used for the emissive layer of the organic EL element.

[0043]

A fluorescent conversion layer 9 serves to convert the color of an irradiated colored light into a different color. In order to obtain the three primary colors of R, G, and B from the color display device while employing a blue emissive material in the emissive layer 14, materials for converting blue into red and green must be used to form the fluorescent conversion layer 9.

[0044]

When converting a blue light emitted from the emissive layer 14 of the organic EL element into a red light, an emissive layer may be provided using a material such as 4-dicyanomethylene-2-methyl-6-(p-dimethylaminostylryl)-4H-pyran (DCM). With this arrangement, a red light can be irradiated from the display pixel.

[0045]

Further, as the material for converting a blue light emitted from the emissive layer 14 of the organic EL element into a green light, a material such as 2,3,5,6-1H,4H-tetrahydro-8-trifluoromethylquinolizino(9,9a,1-gh)coumarin may be used. In this way, a green light can be irradiated from the display pixel.

[0046]

In a display pixel in which a blue light is emitted from the emissive layer 14 of the organic EL element, a blue conversion layer may be provided to increase the blue color purity. In such a case, the conversion layer may be formed using the following blue emissive material.

[0047]

Materials such as oxadiazole (OXD), azomethine-zinc complex (AZM), or Al-quinoline mixed ligand complex with perylene may be employed as the blue emissive material.

[0048]

As described above, in the present embodiment, only one type of blue light emitting material is required as the emissive material for the emissive layer of the organic EL element. Three types of fluorescent conversion materials are simply formed in one layer on the transparent substrate 22. The manufacturing process is thus extremely simplified compared to a conventional device in which three types of emissive layer materials are used in the organic EL element layer for generating the three primary colors.

[0049]

While the generated light from the emissive layer 14 is blue in the present embodiment, the present invention is not limited to that configuration. The generated light from the emissive layer 14 may be another color such as red or green. When the emissive layer generates a red light, the fluorescent conversion layer 9 is formed using materials which convert the red light into blue and green lights. When the emissive layer generates a green light, the fluorescent conversion layer 9 is formed using materials which convert the green light into red and blue lights.

[0050]

As such, light can be radiated towards the side of the transparent insulator substrate 22 provided with the fluorescent conversion layer 9 without being blocked by the TFTs. Accordingly, the display pixels can be designed to have the maximum aperture ratio, and increased freedom is available in selecting the size and driving capability of the TFTs.

[0051]

Furthermore, as the aperture ratio of the display pixels can be enhanced, it is no longer necessary to increase current density to obtain a bright indication. Accordingly, the life of the organic EL element can be extended.

[0052]

Further, as the generated light is emitted via the fluorescent conversion layer 9 arranged over the cathode in the present embodiment, color emitting areas are larger compared to a conventional device in which light is emitted from the TFT substrate side. Accordingly, color indication having increased brightness and vividness can be obtained.

[0053]

While a fluorescent conversion layer 9 is used in the present embodiment, the advantages of the present invention can be similarly achieved when, as in the first embodiment, the emissive layer 14 is adapted to emit white light, and color filters are provided on the transparent insulator substrate 22 in place of the fluorescent conversion layer 9 in the structure of the present embodiment.

<Third Embodiment>

Fig. 3 shows a partial cross-sectional view of an organic EL display device according to a third embodiment of the present invention.

[0054]

The present embodiment differs from the second embodiment in that a groove 26 is formed in the peripheral portions of the insulator substrate 2.

[0055]

The groove 26 is formed by etching the insulator substrate 2 upon arranging a mask having an opening in the area of the groove 25 on the substrate 2.

[0056]

After forming the TFTs on the insulator substrate 2, a desiccant is filled in the groove

26 before adhering, using a sealing agent, the substrate 2 to the transparent insulator substrate 22 having the fluorescent conversion layer 9. After filling of the desiccant, the two substrates 2,22 are adhered to one another by the sealing agent 19 to complete the organic EL display device.

[0057]

Materials such as calcium oxide, phosphorus pentaoxide, calcium chloride, and silica gel may be used as the desiccant to be filled in the groove.

[0058]

With the above arrangement, moisture adsorbed on the seal 19 can be captured by the desiccant filled in the groove 26. In addition, the spacers 25 made of desiccant captures moisture between the transparent insulator substrate 22 and the cathode 17. In this way, deterioration of organic materials due to moisture and the subsequent display degradation can be prevented.

[0059]

While a color filter or a fluorescent conversion layer is provided as a color component in each of the above embodiments, such a color component is unnecessary when color indication is not performed.

[0060]

While the above embodiments referred to TFTs having a bottom gate type structure, the present invention is not limited to such TFTs. The TFTs may also have a top gate type structure wherein a gate electrode is provided above the active layer.

[0061]

[Advantages of the Invention]

According to the present invention, there is provided an organic EL display device in which the aperture ratio of each display pixel is enhanced, and the size and driving capability of the TFT for driving an EL element can be more freely selected. The manufacturing process of the device is simplified by disposing a color component on a separate substrate arranged opposing the substrate having the TFT formed thereon. Furthermore, display degradation due to moisture can be prevented.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a cross-sectional view showing a first embodiment of the organic EL display device according to the present invention.

[Fig. 2]

Fig. 2 is a cross-sectional view showing a second embodiment of the organic EL display device according to the present invention.

[Fig.3]

Fig. 3 is a cross-sectional view showing a third embodiment of the organic EL

display device according to the present invention.

[Fig. 4]

Fig. 4 is a cross-sectional view showing a conventional organic EL display device.

[Reference Numerals]

2 insulator substrate
9 fluorescent conversion layer
12 anode
14 emissive layer
17 cathode
19 sealing agent
22 transparent insulator substrate
24 color filter
25 spacer
26 groove

[Name of the Document] Abstract

[Abstract]

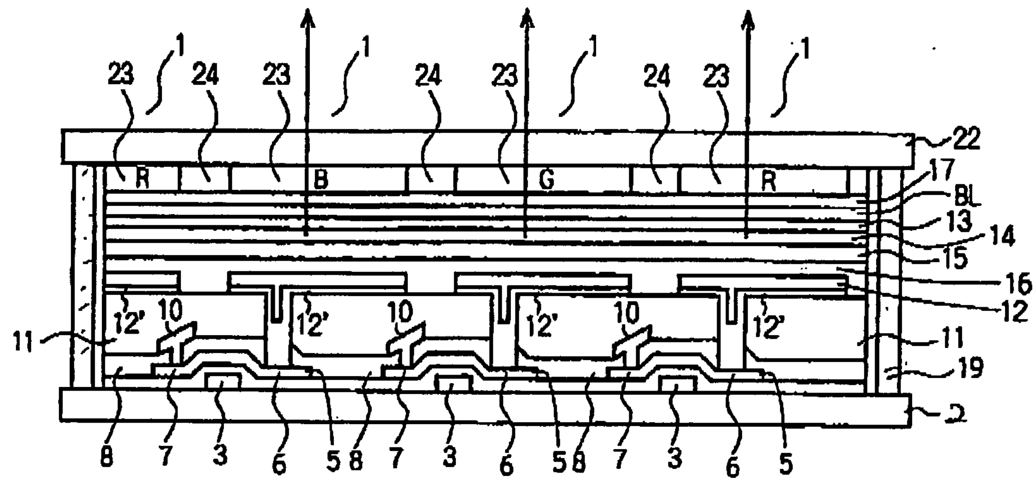
[Object] To provide an organic EL display device which can be designed without being restricted in size and capability of TFTs for driving organic EL elements, and in which display degradation due to moisture is prevented.

[Achieving Means] On an insulator substrate 2, an organic EL element is formed by laminating, in order, a TFT having a source region 9, an anode 12 composed of Mo and ITO and connected to the source region 9, an emissive element layer made of an organic material, and a cathode 17 composed of ITO. This insulator substrate 2 is adhered to a transparent insulator substrate 22 having a color filter 23, using a sealing agent 19 having a desiccant made of calcium oxide mixed therein.

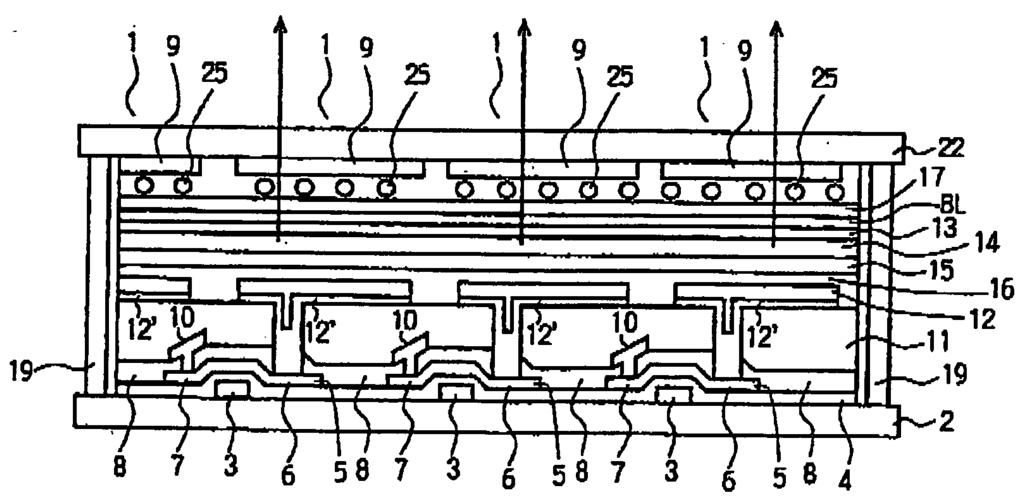
[Selected Drawing] Fig. 1

[Name of the Document] Drawings

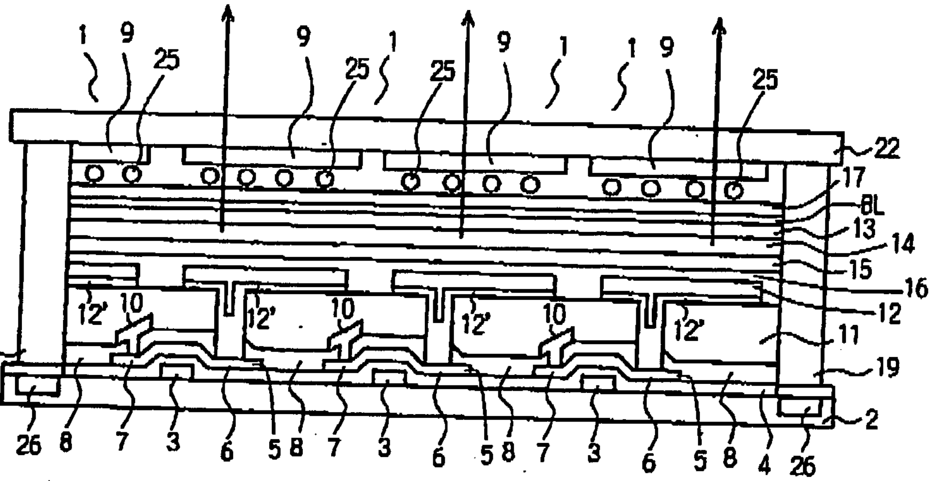
[Fig. 1]



[Fig. 2]



[Fig. 3]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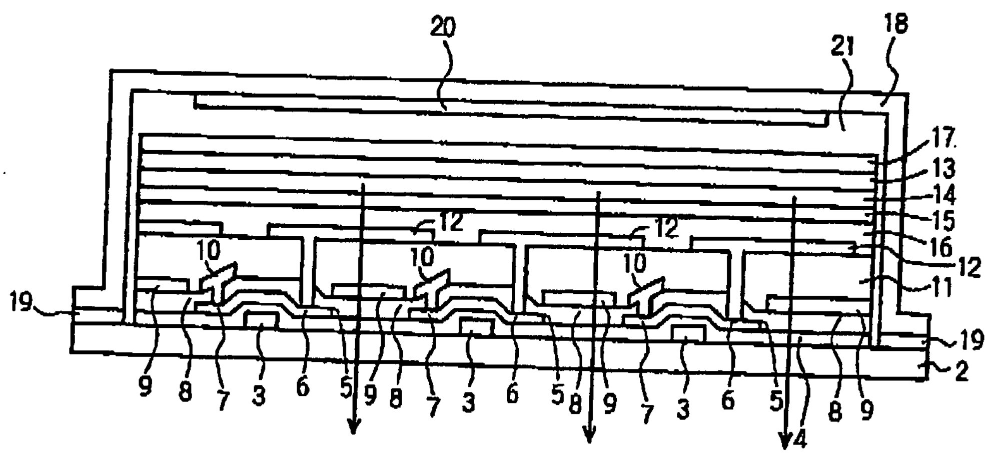
[Fig. 4]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